

**COMPOSITION FOR PREVENTING SCALING, EXCLUDING OF SOOT,
CLINKER AND SLUDGE, AND CONTROLLING FLAME IN COMBUSTION
APPARATUS**

BACKGROUND OF THE INVENTION

5 (a) Field of the Invention

The present invention relates to a water-soluble fuel additive composition comprising borax, sodium hydroxide, an amine-based stabilizer, hydrogen peroxide, and water, which facilitates combustion, increases thermal efficiency, reduces smoke generation, excludes soot and clinker
10 from a furnace, and controls flame, thereby improving the radiant heat transfer system.

(b) Description of the Related Art

Conventionally, removal of soot and clinker in a furnace has been performed physically, and air pollution control has been done by
15 post-treatment. Improvement of thermal radiation systems to enhance thermal efficiency has focused on mechanical aspects. However, operation status of furnaces and characteristics of fuels have caused problems.

To take a gas boiler as an example, hard solid materials such as sludge, which are generated by whitening and the like, may increase gas
20 consumption or cause explosions.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a fuel additive

composition which is added to fuel, such as coal, oil, and gas, to facilitate combustion, exclude impurities such as soot and clinker from a combustion apparatus to facilitate heat transfer, and control flame size, thereby improving the radiant heat transfer system.

5 **BRIEF DESCRIPTION OF THE DRAWINGS**

FIG. 1 is a graph showing the decrease of exhaust gas with time when the fuel additive composition of the present invention has been added to fuel.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

10 The present invention provides a fuel additive composition comprising 8 to 40 parts by weight of hydrogen peroxide, 8 to 40 parts by weight of an amine-based stabilizer, 10 to 40 parts by weight of borax, 16 to 40 parts by weight of sodium hydroxide, and water.

The composition is prepared by dispersing it in water, so that the
15 content of the composition with respect to water ranges from 1:2 to 1:50 by weight.

The fuel additive composition is added at 0.02 to 0.5 parts by weight per 100 parts by weight of fuel.

The composition may further comprise methyl alcohol or a surfactant,
20 in which the content of the composition to them ranges from 1:1 to 1:3 by weight.

The composition may further comprise one or more catalysts selected from the group consisting of potassium carbonate, calcium

carbonate, and sodium carbonate, in which the content of the composition to a catalyst ranges from 1:0.03 to 1:0.3 by weight.

The present invention also provides a method of preparing a fuel additive composition, comprising the steps of:

- 5 mixing 16 to 40 parts by weight of sodium hydroxide in an aqueous solution in which 10 to 40 parts by weight of borax has been dissolved;
- adding 8 to 40 parts by weight of an amine-based stabilizer to the resultant mixture; and
- adding 8 to 40 parts by weight of hydrogen peroxide to the resultant
- 10 mixture.

The present invention further provides a use of the fuel additive composition.

Hereinafter, the present invention is described in more detail.

- The fuel additive composition of the present invention comprises
- 15 hydrogen peroxide, an amine-based stabilizer, borax, sodium hydroxide, and water, and it facilitates combustion of fuel, thereby leading to complete combustion.

- Hydrogen peroxide generates oxygen radicals, and thus facilitates combustion of fuel. Oxygen radicals are oxygen in an atomic state, and
- 20 they are very unstable. Thus, they exist for a very short time and are highly reactive. In the composition of the present invention, hydrogen peroxide generates oxygen radical, thereby facilitating combustion of fuel fed into the furnace and the combustion tube. Therefore, the fuel may burn easily even

with a small amount of oxygen. Also, the oxygen radicals reduce NO_x (thermal NO_x) and prevent generation of PM (particulate matter) such as SO_x and CO in a combustion apparatus.

Because hydrogen peroxide produces oxygen radicals or oxygen molecules even at room temperature, glycerin or an amine-based stabilizer is used to inhibit it. As a result, radicals are generated in a large amount at about 400 °C, which facilitates combustion of fuel. At about 800 °C or above, oxygen radicals from borax facilitate combustion.

The amine-based stabilizer is selected from the group consisting of dimethanolamine, diethanolamine, trimethanolamine, and triethanolamine.

Using the amine-based stabilizer, decomposition is retarded even up to about 180 °C or higher. At about 180 °C or higher, oxygen radicals are generated in a large amount, so that combustion of the fuel is facilitated even with a low oxygen content. The amine-based stabilizer also prevents low-temperature corrosion and increases dispersibility in the aqueous solution, thereby reducing differences of specific gravity of the matter.

Borax, or hydrated sodium borate ($\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$), excludes soot, clinker, and sludge from the furnace of the combustion apparatus, thereby increasing thermal conduction efficiency, and prevents corrosion of the furnace, thereby extending the furnace life.

< 1 > Part of the borax mixed in the fuel is decomposed to generate oxygen radicals, but intact borax is deposited on the furnace surface to form a film, thereby preventing corrosion at elevated temperatures, reducing viscosity of

ash, removing PM such as soot, clinker, and sludge, improving thermal efficiency, and reducing air pollutants (dust, smoke, NO_x, and SO_x). If used in a combustion apparatus, oxygen radicals generated from the fuel additive composition of the present invention reduce generation of thermal NO_x, and
5 sodium included in the mixture forms sodium sulfate, so that SO_x exhausted to the air is reduced.

Borax, which is powder, is added to and dissolved in water. However, because deposition may occur over time, sodium hydroxide and the amine-based stabilizer are added to increase solubility of the borax in
10 water and prevent the deposition.

The fuel additive composition is prepared by dispersing 8 to 40 parts by weight of hydrogen peroxide, 8 to 40 parts by weight of borax, 10 to 40 parts by weight of the amine-based stabilizer, and 16 to 40 parts by weight of sodium hydroxide, in water. The content of the composition to water
15 ranges from 1:2 to 1:50 by weight.

If the content of the components falls outside this range, combustion may be retarded, which causes an increase of fuel use, and cleansing power may be reduced or deposition may occur during dispersing.

The fuel additive composition may further comprise potassium
20 carbonate, calcium carbonate, or sodium carbonate to reduce smoke generation during combustion. They induce low-temperature combustion thereby reducing NO_x generation, and control flame size during combustion thereby improving the radiant heat transfer system and reducing fuel

consumption. The content of the composition of the present invention to the additive ranges from 1:0.03 to 1:0.3 by weight.

The content of the fuel additive composition of the present invention may be controlled appropriately depending on the kind and quality of fuel, operation status of the furnace, and degree of aging. Preferably, it is added at 0.02 to 0.5 parts by weight per 100 parts by weight of fuel. The fuel additive composition enhances cleansing power and prevents low-temperature corrosion and high-temperature corrosion.

The fuel additive composition of the present invention is prepared by the steps comprising:

mixing 10 to 40 parts by weight of borax in an aqueous solution in which 16 to 40 parts by weight of sodium hydroxide have been dissolved;

adding 8 to 40 parts by weight of an amine-based stabilizer to the resultant mixture; and

adding 8 to 40 parts by weight of hydrogen peroxide to the resultant mixture.

Borax is added at 50 to 95 °C to maximize its solubility, and hydrogen peroxide is added at the last step to appropriately control the oxygen radical content. If hydrogen peroxide is mixed along with borax in the first step, oxygen radicals are generated excessively, so that foaming occurs and oxygen radicals are lost. Also, the temperature of the resultant fuel additive composition is elevated, which makes further processing complicated and dangerous.

Potassium carbonate, calcium carbonate, or sodium carbonate is added after addition of hydrogen peroxide.

Any solid, liquid, or gas fuel may be used in the present invention. For example, a solid fuel such as coal, coke, and charcoal, a liquid fuel such as gasoline, kerosene, light oil, heavy oil, coal tar, oil sand, oil shale,
5 as methanol, and ethanol, and a gaseous fuel such as natural gas, liquefied petroleum gas, hydrogen, and acetylene may be used.

The fuel additive composition of the present invention burns carbon particles (e.g. coal) before ashing, thereby preventing coagulation of carbon
10 particles with ashes and altering film formation of borax and the viscosity of ashes, so that deposition of clinker, soot, and sludge in the furnace can be prevented.

Particularly, under the reducing atmosphere in the furnace, the ashing point is decreased. The fuel additive composition of the present
15 invention checks a decrease of the ashing point by oxygen radicals, thereby preventing clinker generation. Also, borax, which penetrates into the pores of coal, prevents coagulation of ashes by a glass bead reaction. Undecomposed borax is deposited on the furnace surface to form a film, thereby preventing high-temperature corrosion, interfering with clinker
20 deposition, and enhancing thermal efficiency.

In a preferred embodiment, if the fuel additive composition of the present invention is employed in a gas boiler, it prevents generation of sludge and reduces energy consumption.

In a gas boiler, fine dust included in air which has been taken in for combustion, may be hardened by whitening and the like to form solid materials like sludge to a thickness of about 1 to 2 mm. When the fuel additive composition of the present invention is used, it decreases the melting point and flashing point, thereby removing the sludge or preventing sludge generation. For example, when the fuel additive composition of the present invention was dispersed in water in a proportion of 1:40 and employed in a 20 ton/H gas/oil combined rotary boiler of H apartment, the flame turned an orange color and elongated, and about 5% of energy consumption was saved.

In another preferred embodiment, if the fuel additive composition of the present invention is employed in a gas turbine, it removes dust attached to the blade of the turbine. The dust induces vibration when the gas turbine is operated at high speed. The fuel additive composition of the present invention removes the dust and rapidly burns dust and soot, thereby enabling effective high-speed operation and offering about 2% of thermal efficiency improvement.

In another preferred embodiment, the fuel additive composition of the present invention may be mixed with light oil for a diesel engine to reduce energy consumption. To be specific, the fuel additive composition is mixed with light oil for a diesel engine along with methyl alcohol or a surfactant. As a result, dust generation during combustion can be reduced and about 9% of energy consumption can be saved.

In another preferred embodiment, the fuel additive composition of the present invention is dispersed in water to increase the Hardgrove grindability index (HGI) of fine coals by about 10%, reduce ash generation by facilitating combustion, and enable recycling of coal ashes. Also, if the composition is sprayed to or mixed with coal, briquettes, coke, or charcoal, combustion is facilitated and smoke and noxious smells can be significantly reduced. Especially, when potassium carbonate is mixed with the composition, smoke generation is reduced, low-temperature combustion is facilitated thereby decreasing discharge of such noxious exhaust gas as NO_x, and the radiant heat transfer system is improved during combustion of gas fuel, thereby leading to reduced fuel consumption.

In another preferred embodiment, the fuel additive composition of the present invention may be a simple salt treated in a cement kiln to improve combustion rate per unit area of a kiln and reduce clinker productivity. In general, combustion rate is determined by flame length. The fuel additive composition of the present invention induces complete combustion and thus reduces flame length. And, in the case of porous coal fuel, borax penetrates deep into the pores of the coal and generates oxygen radicals at elevated temperatures. A melting point decrease and porosity enhancement by calcium carbonate or sodium carbonate increases a contact area of oxygen thereby increasing the combustion rate, reducing flashing temperature, and reducing smoke generation from a Ringelmann turbidity of level 3 to level 1.

In still another preferred embodiment, the fuel additive composition of the present invention is employed in an oil boiler to induce complete combustion of fuel, thereby reducing fly ash, improving dust collecting efficiency, and extending catalyst life of a dust collector. To be specific, 5 when the composition was sprayed into the combustion chamber of an oil boiler while being dispersed in water, about 3% of fuel consumption was saved and sludge inside the boiler was removed. Also, generation of dust and smoke was reduced and scale and sludge generated in the pre-heater was removed.

10 Thus, the fuel additive composition of the present invention may be used for a combustion apparatus to remove scale, to prevent corrosion, soot generation, clinker generation, and sludge generation, and to control flames.

Hereinafter, the present invention is described in more detail through examples. However, the following examples are only for the understanding 15 of the present invention and they do not limit the present invention.

EXAMPLES

Example 1

30 kg of borax and 20 kg of sodium hydroxide were dissolved in 50 kg of water at 70 °C. Then, 20 kg of triethylamine, 20 kg of hydrogen 20 peroxide, and 10 kg potassium carbonate were added to prepare a fuel additive composition. The resultant fuel additive composition experienced no precipitation or deposition of borax, and remained as a stable aqueous solution.

Comparative Example 1

A fuel additive composition was prepared as in Example 1, without using sodium hydroxide. The resultant composition experienced precipitation as time went by.

5 Comparative Example 2

A fuel additive composition was prepared as in Example 1, at a temperature of 40 °C. The resultant composition experienced precipitation as time went by.

Comparative Example 3

10 A fuel additive composition was prepared as in Example 1, at a temperature of 45 °C. The resultant composition experienced precipitation as time went by, as in Comparative Examples 1 and 2.

Comparative Example 4

30 kg of borax, 20 kg of sodium hydroxide, and 30 kg of hydrogen
15 peroxide were dissolved in 50 kg of water at 70 °C. Then, 20 kg of triethylamine, 20 kg of hydrogen peroxide, and 10 kg potassium carbonate were added to prepare a fuel additive composition. The temperature of the resultant fuel additive composition rapidly rose to 100 °C as time went by. This is because of excessive generation of oxygen radicals, which is caused
20 by addition of hydrogen peroxide.

Testing Example 1: Energy efficiency test

An energy efficiency test was performed for the composition of Example 1.

Coal having a moisture content of 1.73%, an ash content of 14.73%, and a volatile content of 30.12% (calorific value = 6,977 kcal; ash fusion temperature (FT) = 1,588 °C), and a boiler having a steam production capacity of 10 ton/h were used. The boiler was operated under a pressure of 8 kPa with a load of 80%. As a result, 16.8% of coal consumption was saved.

Testing Example 2: Pollution reduction test

Dust content, sulfur dioxide concentration, and Ringelmann turbidity were measured for the composition. The results are shown in the following

Table 1.

Table 1

Test items	Before measurement	After measurement	Measurement result
Average dust content (mg/Nm ³)	1673.8	1082.3	Decreased by 35.3%
Average dust discharge amount (kg/h)	42.5	26.9	Decreased by 36.7%
Average sulfur dioxide concentration (mg/ Nm ³)	321.5	249.1	Decreased by 22.5%
Average sulfur dioxide discharge amount (kg/h)	8.158	249.1	Decreased by 24.1%
Ringelmann turbidity (smoke concentration)	1	1	Same

Testing Example 3: Fuel consumption saving test

The composition was employed in a combined heat and power plant using bituminous coal. Fuel consumption saving effect due to reduction of air pollutants and clinkers was determined.

The composition was diluted to about 1,000:1, based on the coal weight, in water, and sprayed on lump coal placed on a coal feeder. The lump coal was crushed to 200 mesh or below and burnt with a burner.

A boiler having a steam production capacity of 120 ton/h and Chinese Tatong bituminous coal (calorific value = 6,600 kcal/kg; ash fusion temperature = 1,180 °C; sulfur content = 0.8%) were used. Fuel consumption was 300 ton/h and temperature inside the furnace was 1,300 to 1,700 °C. A horizontal firing type burner and a natural circulation type boiler were used.

10 A. Air pollutants generation reduction effect

Dust content, SO_x concentration, NO_x concentration, and CO concentration were measured for 4 weeks.

1. Dust content: Measured with a cylindrical filter. Before addition of the composition, average dust content was 19.4 mg/cm². It decreased
15 by about 47.0%.

2. SO_x concentration: Measured by precipitation titration method. SO_x concentration decreased by about 10.2%.

3. NO_x concentration: Measured by zinc 1-naphthyldiamine method. NO_x concentration decreased by about 13.0%.

20 4. CO concentration: Measured by nondispersive infrared analysis method. CO concentration decreased by about 27%.

B. Fuel efficiency improvement effect

Fly ash content decreased from 30.8% to 13.0%, which is about

57.8%.

Additionally, the content of bottom ash, one of the clinkers, decreased from 59.0% to 25.0%, which is about 57.6%.

C. Clinker removal effect

5 Although the coal used in the test had a lower ash fusion temperature of 1,180 °C than those commonly used (1,300 to 1,400 °C), no clinker was observed on the furnace wall or in the super heater. Also, there was no fouling.

Testing Example 4: Fuel consumption saving test

10 The following test was performed to confirm clinker removal and thermal efficiency improvement.

 The composition diluted in water was sprayed on crushed coal. The proportion of coal, water, and the composition was 1000:10:1. The mixture was sprayed on lump coal on a coal feeder. The coal was crushed
15 to 200 mesh or below and burnt with a burner.

 The coal had a moisture content of about 2.36%, an ash content of about 27.89%, and a volatile content of about 17.97%. A horizontal firing type boiler was used. Steam production capacity was 220 ton/hr, and vapor pressure was 9.8 MPa. The temperature inside the furnace was
20 1,500 °C to 1,700 °C, the air ratio was about 4.8, the combustion exhausting temperature was 120 °C, and the vapor temperature was about 540 °C.

A. Fuel saving effect

Coal to which the fuel additive composition of the present invention had been added was used for 14 days. 76,710 tons of vapor were produced with 9,786.54 kg of coal. When only coal was used for 15 days, 68,462 tons of vapor were produced with 9,910.58 kg of coal. Therefore, the fuel additive composition of the present invention offers better fuel efficiency.

B. SO_x reduction effect

Exhaust gas reduction effect with time was evaluated for coal to which the composition of Example 1 (C1) had been added, and the composition (C2) which had been prepared by adding 10 wt% (10 kg) of potassium carbonate and to which no additive had been added.

The test condition was as follows. The results are shown in FIG. 1.

Measuring device: Test 350M/XL (manufactured by TESTO)

Measuring method: Static potential chemical type

Measuring device type approval number: ASGAM-2001-6 (National Institute of Environmental Research)

Measuring device performance test report: Prepared by Korea Testing Laboratory

In FIG. 1, #1 and #2 (-□-, -◇-) show SO_x discharge when the composition of Example 1 was not added. -▲- is when C1 only was added, -◆- is when 10 wt% of C2 was added along with C1, and -■- is when 15 wt% of C2 was added along with C1.

Using the fuel additive composition of the present invention, fuel exhaust gas discharge decreased from about 1,100 ppm to about 600 ppm on average. Therefore, SO_x reduction effect was about 45%.

C: Fine particle removal in fly ash

5 Fine particle content was measured for 6 days for Boiler No. 1 to which the composition of the present invention had been added, and Boiler No. 2 to which the composition had not been added.

Fine particle content of Boiler No. 1 was 7.39% and that of Boiler No. 2 was 8.76%. Thus, fine particle content was decreased by about
10 15.64%.

As described above, the fuel additive composition of the present invention reduces dust, SO_x, and NO_x generation and induces complete combustion thereby reducing fuel consumption, and prevents soot, clinker, sludge, and corrosion in a combustion apparatus, thereby enhancing heat
15 transfer efficiency and improving operation stability.